VERIFICATION TEST

OF

STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES

FOR

DUANE ARNOLD ENERGY CENTER

IOWA ELECTRIC LIGHT AND POWER COMPANY

JOB 11186-232

Prepared By
Bechtel Associates Professional Corporation
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ATTACHMENTS

1.0 TASK OBJECTIVE

This report provides a description of the methods used and the results of a verification test of the station electric distribution system voltages for the Duane Arnold Energy Center (DAEC). The test was performed to verify analyses of the adequacy of the offsite and onsite distribution system of DAEC. The analysis and test were performed in accordance with the NRC letter to all power reactor licensees dated August 8, 1979.

The test was conducted at the DAEC on April 13, 1980, during the refueling outage.

2.0 LIGHT LOAD ON STARTUP TRANSFORMER

The procedure for this test involved the following:

2.1 Verify that the startup transformer is supplying all required plant auxiliary loads for this case.

2.2 Verify that the actual test light load does not exceed the estimated light load.

2.3 Record the steady-state voltages and currents for all safety-related buses.

A summary of the test results and analysis is provided in Table 1 as described below.

Column 1 indicates the actual measured values taken at the DAEC on April 13, 1980.

Column 2 indicates calculated values determined through a load flow computer simulation of the DAEC auxiliary power system. The measured input data such as switchyard voltage, running load, and starting load were entered into the computer program. The resulting voltages at the different buses were calculated and are listed.

Column 3 indicates the percent variance of calculated voltage values from measured values. The calculated results are within $\pm$ 1.2% of the measured values, which indicates a very good correlation. As such, the test results verify the auxiliary system model for light load conditions supplied by the startup transformer.

Column 4 indicates calculated values which represent an extrapolation to the maximum system voltage for light load. Maximum voltage at the switchyard (105%) results in a high value of 110.8% (460 V base) on 480 V load center 1B3, which is judged to be acceptable.

Note that the total safety-related auxiliary system load measured was 1.928 MVA versus 2.735 MVA which had been previously estimated in the analysis. This was expected because the plant was in a refueling outage condition when these measurements were taken. It is anticipated that this measured condition is by far the lightest load that will be experienced. During normal operation, it is expected that the total loading will be somewhat greater, and consequently the voltages will be somewhat lower.

In summary, the test results verified that the system, when connected to the startup transformer, performs satisfactorily under light load for maximum switchyard voltage.

3.0 LIGHT LOAD ON STANDBY TRANSFORMER

The procedure for this test involved the following:

3.1 Verify that the standby transformer is supplying all required plant auxiliary loads for this case.

3.2 Verify that the actual test light load does not exceed the estimated light load.

3.3 Record the steady-state voltages and currents for all safety-related buses.

A summary of the test results and analysis is provided in Table 2 as described below.

The measured results and corresponding calculated values of this table follow the same sequence and rationale as described for Table 1. Again, the calculated values for the duplicate cases exhibit good correlation with the measured values ($\pm$ 2.5%). This in turn verifies the computer auxiliary system model for light load conditions supplied by the standby transformer.

Extrapolation to the maximum system voltage for light load is indicated in Column 4. Maximum voltage at the switchyard (105%) results in a high value of 110.1% (460 V base) on 480 V load center 1B4, which is judged to be acceptable. As discussed for Table 1, this measured condition is by far the lightest load expected.

In summary, the test results verified that the system, when connected to the standby transformer, performs satisfactorily under light load for maximum switchyard voltage.

4.0 LOCA ON STANDBY TRANSFORMER

The procedure for this test involved the following:

4.1 Verify that the standby transformer is supplying all required plant auxiliary loads and is available for starting all required safety-related loads on LOCA.

4.2 Align all core spray and RHR pumps for full-flow test operation.

4.3 Connect LOCA test switch to simulate accident conditions.

4.4 Start recorders.

4.5 Turn LOCA test switch to the test position.

4.6 Verify that all LOCA loads started.

4.7 Restore station to normal conditions.

A summary of the test results and analysis is provided in Table 3 as described below.

Column 1 indicates the actual measured values taken at the DAEC on April 13, 1980. The values shown are minimum values which occurred approximately 0.45 second after test initiation.

Column 2 indicates calculated values determined through the use of the load flow computer simulation of the DAEC auxiliary power system.

Column 3 indicates the percent variance of the calculated voltage values from measured values. Note that the variance for the voltage reading on 480 V load center 1B3 is +14.5%. Review of the voltage traces before trip of the LOCA simulation switches indicates that the trace for 480 V load center 1B3 was miscalibrated. The trace shows a voltage value of 93.7% (460 V base). The expected value, based on a straight-forward voltage drop calculation using the measured current, is 109.1% (460 V base). This provides evidence that the subject trace was miscalibrated. The other variances are within $\pm$ 4.8%, which is deemed to be an acceptable correlation.

Column 4 indicates calculated values which represent an extrapolation to the minimum system voltage for a LOCA on the standby transformer. Minimum voltage at the switchyard (95%) results in a low value of 82.9% (460 V base) on 480 V load center 1B4, which is judged to be acceptable based on an acceptance criterium of 82.67% (460 V base)

An acceptance criterium of 87.4% (460 V base) had been generated as part of the analysis that was communicated to the NRC in our previous submittal. This criterium was based on the requirement of 80% (460 V base) terminal voltage at the terminals of a specific motor-operated valve. A separate test was conducted for that motor-operated valve, and verified that the valve will stroke with 67.4% (460 V base) terminal voltage. It may, in fact, stroke at a lower voltage, but the available voltage source (onsite diesel generator) could not be adjusted to a lower voltage value. This value translated to a value of 74.8% (460 V base) at the 480 V load center buses. Because this valve is no longer the worst case, the other various motor-operated valves become the limiting condition with 82.6% (460 V) required at the 480 V load center bus. This value is based on an 80% (460 V) terminal voltage at the other various motor-operated valves. Consequently, this is judged to be a conservative criteria.

Voltages on 480 V load centers 1B20 and 1B9 fall to lows of 71.1% and 78.5% (460 V base), respectively. This is acceptable because no automatic pickup of loads is required on these load centers for a LOCA with offsite power available. Continued system operation is required, and therefore dropout of motor control center contactors becomes a concern. Dropout for the contactors is in the range of 58%; therefore, this voltage is acceptable.

Review of the voltage traces indicated that the voltages reached the minimum at approximately 27 cycles after initiation of the LOCA simulation. At approximately 161 cycles (approximately 2.7 seconds), the voltages recovered to near nominal values. The recovered voltage values are as follows:

Bus	Voltage (motor voltage base) (%)
1A3	107
1A4	104
1B3	91
1B4	105
1B9	99
1B20	99

This recovery time (2.7 seconds) is well below the melting time for motor control center control circuit fuses and the trip time for motor overloads. This fast response or recovery of the system is added assurance that adequate voltage will be available and that the system will perform as intended under worst-case conditions.

Although small current variations were observed, no measurable quantity of starting loads was noted on 480 V load center buses 1B3 and 1B4. There was no apparent effect on the associated bus voltages.

In summary, the test results verified that the system, when connected to the standby transformer, performs satisfactorily under LOCA, for minimum grid voltage.

5.0 LOCA ON STARTUP TRANSFORMER

This particular loading situation was not specifically investigated by test. An analysis was conducted with the same input values for the safety-related buses that were measured for the LOCA on the standby transformer. The calculated values indicate that the system will perform satisfactorily under the given situation.

Additionally, the LOCA on the standby transformer is judged to be the worst case, based on the fact that the standby transformer is a smaller capacity (MVA) transformer than the startup transformer. This was verified by the calculated values.

6.0 CONCLUSION

In summary, the test and analysis verified that the offsite and onsite electrical distribution system at the DAEC has sufficient capacity to perform its intended function as designed.

TABLE 1

LIGHT LOAD ON STARTUP TRANSFORMER

	Measured Test Values (%)			Duplicate Analysis Values (%)			Percent Variance of Calculated From Measured (%)	Maximum System Voltage Case Values (%)		
161 kV switchyard voltage	104.2			104.2			--	105		
Tap Settings										
Startup	1.0			1.0			--	1.0		
LC 1B3	.975			.975			--	.975		
LC 1B4	.975			.975			--	.975		
	Volt	LDRN	LDST	Volt	LDRN	LDST	Voltage	Volt	LDRN	LDST
Safety-related bus data										
4 kV buses										
1A3	107.0	.245	0	108.2	.245	0	+1.2	109.0	.245	0
1A4	107.0	.66	0	108.1	.66	0	+1.1	108.9	.66	0
480 V LC buses										
1B3	110.9	.445	0	110.0	.445	0	-0.9	110.8	.445	0
1B4	110.9	.482	0	109.8	.482	0	-1.1	110.6	.482	0
1B9	106.5	.052	0	105.6	.052	0	-0.9	106.4	.052	0
1B20	106.5	.044	0	105.6	.044	0	-0.9	106.4	.044	0

Notes:

-- = Not applicable for stated case
Volt = Percent voltage at bus on motor voltage base
LDRN = Running load at bus in MVA
LDST = Starting load at bus in MVA

TABLE 2

LIGHT LOAD ON STANDBY TRANSFORMER

	Measured Test Values (%)			Duplicate Analysis Values (%)			Percent Variance of Calculated From Measured (%)	Maximum System Voltage Case Values (%)		
161 kV switchyard voltage	103.4			103.4			--	105		
Tap Settings										
Standby	1.0			1.0			--	1.0		
LC 1B3	.975			.975			--	.975		
LC 1B4	.975			.975			--	.975		
Safety-related bus data	Volt	LDRN	LDST	Volt	LDRN	LDST	Voltage	Volt	LDRN	LDST
4 kV buses										
1A3	105.5	.292	0	106.6	.292	0	+1.1	108.3	.292	0
1A4	105.5	.694	0	106.6	.694	0	+1.1	108.3	.694	0
480 V LC buses										
1B3	110.4	.475	0	108.2	.475	0	-2.2	110.0	.475	0
1B4	110.4	.439	0	108.3	.439	0	-2.1	110.1	.439	0
1B9	106.5	.037	0	104.2	.037	0	-2.3	105.8	.037	0
1B20	106.5	.037	0	104.0	.037	0	-2.5	105.7	.037	0

Notes:

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LDRN = Running load at bus in MVA
LDST = Starting load at bus in MVA

TABLE 2

LOCA ON STANDBY TRANSFORMER

	Measured Test Values (%)			Duplicate Analysis Values (%)			Percent Variance of Calculated From Measured (%)	Minimum System Voltage Case Values (%)		
161 kV switchyard voltage	103.65			103.65			--	95		
Tap Settings										
Standby	1.0			1.0			--	1.0		
LC 1B3	.975			.975			--	.975		
LC 1B4	.975			.975			--	.975		
Safety-related bus data	Volt	LDRN	LDST	Volt	LDRN	LDST	Voltage	Volt	LDRN	LDST
4 kV buses										
1A3	88.4	.463	.904	90.7	.463	.904	+2.3	82.8	.463	.904
1A4	95.5	.478	1.751	90.7	.478	1.751	-4.8	82.8	.478	1.751
480 V LC buses										
1B3	77.0	.494	0	91.5	.494	0	+14.5*	83.2	.494	0
1B4	88.7	.557	0	91.3	.557	0	+2.6	82.9	.557	0
1B9	83.5	.258	0	86.5	.258	0	+3.0	78.5	.258	0
1B20	83.5	.557	0	80.1	.557	0	-3.4	71.1	.557	0

Notes:

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Volt = Percent voltage at bus on motor voltage base
LDRN = Running load at bus in MVA
LDST = Starting load at bus in MVA

*Miscalibration in measured value, see text Section 4.0.

TABLE 4

LOCA ON STARTUP TRANSFORMER

	Minimum System Voltage Case Values (%)		
161-kV switchyard voltage	95		
Tap Settings			
Startup	1.0		
LC 1B3	.975		
LC 1B4	.975		
	Volt	LDRN	LDST
Safety-related bus data			
4-kV buses			
1A3	89.2	.463	.904
1A4	86.7	.478	1.751
480-V LC buses			
1B3	89.9	.494	0
1B4	87.1	.557	0
1B9	84.9	.258	0
1B20	79.2	.557	0
Nonsafety-related bus data			
4-kV buses			
1A1	89.2	11.513	0
1A2	86.7	11.513	0
480-V LC buses			
1B1	81.9	1.25	0
1B2	79.4	1.25	0
1B5	79.7	1.5	0
1B6	77.0	1.5	0
1B7	77.0	2.0	0
1B8	74.2	2.0	0

NOTES:

Volt = Percent voltage at bus on motor voltage base
LDRN = Running load at bus in MVA
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TABLE 1

LIGHT LOAD ON STARTUP TRANSFORMER

	Measured Test Values (%)			Duplicate Analysis Values (%)			Percent Variance of Calculated From Measured (%)	Maximum System Voltage Case Values (%)		
161 kV switchyard voltage	104.2			104.2			--	105		
Tap Settings										
Startup	1.0			1.0			--	1.0		
LC 1B3	.975			.975			--	.975		
LC 1B4	.975			.975			--	.975		
	Volt	LDRN	LDST	Volt	LDRN	LDST	Voltage	Volt	LDRN	LDST
Safety-related bus data										
4 kV buses										
1A3	107.0	.245	0	108.2	.245	0	+1.2	109.0	.245	0
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TABLE 2

LIGHT LOAD ON STANDBY TRANSFORMER

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161 kV switchyard voltage	103.4			103.4			--	105		
Tap Settings										
Standby	1.0			1.0			--	1.0		
LC 1B3	.975			.975			--	.975		
LC 1B4	.975			.975			--	.975		
Safety-related bus data	Volt	LDRN	LDST	Volt	LDRN	LDST	Voltage	Volt	LDRN	LDST
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1B20	83.5	.557	0	80.1	.557	0	-3.4	71.1	.557	0

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LOCA ON STARTUP TRANSFORMER

	Minimum System Voltage Case Values (%)		
161-kV switchyard voltage	95		
Tap Settings			
Startup	1.0		
LC 1B3	.975		
LC 1B4	.975		
	Volt	LDRN	LDST
Safety-related bus data			
4-kV buses			
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1B9	84.9	.258	0
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Nonsafety-related bus data			
4-kV buses			
1A1	89.2	11.513	0
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1B5	79.7	1.5	0
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1B8	74.2	2.0	0

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LDST = Starting load at bus in MVA